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Japan Report

(FOUO 58/81)

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SCIENCE AND TECHNOLOGY

PRESSURES FOR DEFENSE BUILDUP INCREASES

Among Business Leaders

Tokyo THE JAPAN ECONOMIC JOURNAL in English No 971, 8 Sep 81 pp 1, 15

[Article by Naoaki Okabe, correspondent, NIHON KEIZAI SHIMBUN]

[Text]

Debates among top business leaders on the defense issue are becoming more heated lately. The Japan Federation of Economic Organizations (Keidanren) plans to discuss the matter at its top policy research committee, while the defense production committee of the business organization will work out details about proposed exchange of defense technology with the United States and businessmen's requests with regard to the nation's medium-term defense buildup program. (See feature stories on Page 11.)

Business leaders showed strong interest in the defense issue at the forum organized by Keidanren in Karuizawa last month. Masamichi Inoki, director of Research Institute for Peace and Security, stressed the need to strengthen Japan's defense capabilities and reorganize the defense setup to meet a possible emergency. Most of the participating businessmen made a positive response to Inoki's remarks.

Bunichiro Tanabe, chairman of Mitsubishi Corporation, said, "It is about time the Government lifted the ban on export of arms to foreign countries."

Hirokichi Yoshiyama, chairman of Hitachi, Ltd., stressed the need to improve research-development systems, such as for precise guided munition (PGM).

Shinpei Omoto, an advisor to Mitsui Mining & Smelting Co., Ltd., said, "We must attach great importance to the backup system, such as reserves of vital metals to be used for arms production."

Keidanren hopes to take up these subjects and further discuss them at the policy discussion meeting, headed by Yoshihiro Inayama, chairman of Keidanren, and participated by top business leaders, including Haruo Suzuki, chairman of Showa Denko K.K., Ryoichi Kawai, president of Komatsu Ltd., and Takashi Ishihara, president of Nissan Motor Co., Ltd.

It is believed that the defense production committee, which consists of defense equipment makers, suggested that the defense issue be discussed at the policy discussion meeting.

Keidanren and its defense production committee, headed by Gakuji Moriya, former chairman of Mitsubishi Heavy Industries, Ltd., have been urging the Defense Agency and other organizations concerned to increase the ratio of capital spending to total defense expenditures to 30 per cent like that of other industrial countries for fiscal 1982, compared with 25.7 per cent for fiscal 1981. The capital spending is to be used for purchase of military equipment, research and development, and maintenance of the defense facilities.

They also insist that the research and development cost should account for at least 2 per cent of the total defense expenditures, compared with 1.04 per cent of the fiscal 1981.

The defense production committee will also discuss major issues of the defense industry at newly-established sub-

committees with main focus on Japan-U.S. technology exchange in the military field, and make recommendations to the Government.

With regard to the military technology exchange between Japan and the U.S., the financial circles are ready to consider it actively as is shown in the remark made by Moriya: "It is very natural for Japan and the U.S. to cooperate with each other as allied countries for development of technology."

Some people also pointed out that it is important to improve military technology indirectly through a joint development effort not only in the field of purely military technology but also in the field of high technology, such as very large-scale integrated circuit and next-generation computers.

Another issue to be discussed at the defense production committee is the 1981 intermediate estimate for the fiscal 1983-1987 defense plan. The committee will emphasize increasing defense spending to improve the quality of defense efforts as to equipment and research development while trying to increase the quantity of defense expenditures itself.

Some of the Liberal Democratic Party Dietmen suggest that the outline for the defense plan, which is the basis for the intermediate defense estimate, be reviewed so that the defense budget will be increased to account for more than the present ceiling of 1 per cent of GNP.

There is a widespread view among the financial circles that even if the defense spending reaches 2 per cent of the nation's GNP, it is still very low by international comparison.

The defense spending is likely to go over 1 per cent of GNP when the outline for defense plan is realized. And the financial circles are likely to step up their voice that the defense budget should not be restricted by the government policy to keep it within 1 per cent of GNP.

The business leaders are showing such a great interest in the defense issue from the belief that Japan should strengthen its defense capabilities as a Western ally in order to maintain military superiority of the West over the East.

And yet, some business leaders take a rather cautious view on the stepped-up talk on the defense issue. Shojiro Kikuchi, chairman of Nippon Yusen Kaisha, showed some skepticism about the recent anti-Soviet hardline policy of the U.S. administration of President Ronald Reagan.

Many of them fear that mounting defense expenditures may lead to a military-dependent economy despite the fact that Japan's economic growth was achieved due to a relatively small defense burden in the past.

Defense Agency Budget Increase

Tokyo THE JAPAN ECONOMIC JOURNAL in English No 971, 8 Sep 81 p 10

[Article by Ichiyo Hino]

[Text] The Defense Agency last week submitted to the Ministry of Finance a request for ¥2,580 billion as its budget for fiscal 1982 — a figure 7.5 per cent up from the current fiscal year's actual budget.

This increase was the maximum granted exceptionally to defense budget when other budget requests were held to a "zero increase."

It manifests the strong intent of the Defense Agency to establish the basis for achieving its 1976 defense outline by fiscal 1987.

The most noteworthy point in its request is that the Agency tried the utmost to meet U.S. demands for greater defense efforts, expressed repeatedly in the U.S.-Japan summit talks last May, working-level defense consultations in Hawaii and the talks between Japan's Defense Agency chief Joji Omura and Defense Secretary Caspar Weinberger in Washington in July. The U.S. demand was that Japan should enhance its preparedness for emergency by modernizing its equipment very quickly, thereby strengthening the capability of Self-Defense Forces and the U.S.-Japan Security Treaty — "two pillars of Japanese defense" — and share a greater defense burden as a member of the Western camp.

Specifically, the U.S. demand called for: 1) modernizing military equipment to improve air defense and anti-submarine warfare; 2) strengthening its preparedness for an emer-

gency; 3) expanding the holding capacity; 4) strengthening command, control and communications; and 5) shouldering a greater burden to pay up the cost of stationing U.S. forces in Japan. The budget requests of the Defense Agency seemed to accept those specific U.S. demands to a considerable extent. For example, the Agency asked for budgeting 43 F15 interceptors, all of the rest of the planned 100, and also 17 anti-submarine patrol planes out of the remaining 27 of the planned 45. As regards enhancing preparedness, the Agency is planning to bring up the quota sufficiency ratio of the frontline forces in Hokkaido closer to 100 per cent by raising the ratio of the entire Ground Self-Defense Forces by 0.7 per cent, and also increase reserve officers of the GSDF.

In an attempt to expand the holding capacity, the Agency placed heavy emphasis on expanding ammunition reserves — by 34.5 per cent for the GSDF, 110 per cent for the maritime and 130 per cent for the air forces. Also to enhance the air defense of previously vulnerable bases and troops, the Agency is asking for budgeting for a total of 100 short-range surface-to-air guidance missiles and portable surface-to-air guidance missiles.

The fundamental concept of Japanese defense is to "expel small-scale and limited invasions with its self-defense forces, but wait for the U.S. forces to come to rescue in case of large-scale invasions." But until recently it is a fact that the self-defense forces have not placed much emphasis on expanding combat capability in its modernization program and could hardly cope even with the "small-scale and limited invasions" they themselves imagine. Thus, unless something is done about correcting the present situation, it is apparent that two pillars of Japanese defense — the SDF and the security treaty — will collapse in case of emergency. In this sense, the Agency's budget requests should be evaluated highly from the standpoint that it is trying to achieve the targets of the 1976 defense outline.

But the problem is a strain caused by meeting the U.S. demand for Japan's "faster and larger" defense buildup. Especially since the Agency asked for earlier-than-scheduled budgeting of F15s, P3Cs, ammunitions and constructions of warships, the financial burden to be shouldered in later years has totaled a massive ¥2,260 billion which cannot be ignored. From a long-range standpoint, it is unavoidable that Japan has to take a greater defense burden in an attempt to placate U.S. criticisms for Japan's "free-ride" and maintain the stable bilateral relations, but it is necessary to put priorities on budgeted items, thereby improving the defense capability more efficiently than before.

Business Wants Priorities

Tokyo THE JAPAN ECONOMIC JOURNAL in English No 971, 8 Sep 81 p 11

[Text]

Defense industry leaders believe that Japan should place top priority on attaining the defense equipment level cited in the Principles of the Defense Buildup Program of 1976 rather than on meeting the defense buildup demands now being made by the United States. They also believe that, in order to attain such a goal, Japan should not worry too much about defense-related expenses overshooting the 1 per cent framework of its GNP.

As to technological assistance to the United States in such fields as communications and electronic equipment, however, most defense industry leaders are for complying with the Americans' requests. They are dissatisfied with the Japanese Government's present arms export policy and believe that the existing three negative principles on arms exports should be slackened.

These and many other interesting facts have been uncovered by a survey recently conducted by the Nihon Keizai Shimbun of the 18 defense industry leaders who comprise the board of directors of the Defense Production Committee of *Keidanren* (Federation of Economic Organizations).

Quality of equipment

President Mankichi Tateno of Japan Steel Works spoke for many when he answered that Japan should first of all tackle the realization of the Principles of the Defense Buildup Program of 1976 by swiftly modernizing its defense equipment and then — only then — should try to comply with the Americans' demands. This view is virtually identical to

that of the present Suzuki Cabinet. Many pollees believed that extra emphasis should be placed on quality as well as on quantity of defense equipment in the future buildup program.

Chairman Yoshio Yagi of Shin Meiwa Industry stated that the Government should speed up the completion date of the Principles of the Defense Buildup Program from the presently-agreed fiscal 1987. While President Masao Kinoshita of Hitachi Shipbuilding & Engineering stated that Japan should build up its defense capability step by step, and not overnight, no one accepted the idea that the defense program might be delayed because of considerations for restoration of Government finances and welfare measures. This shows that, while Japanese defense industry leaders are not exactly agreed on revamping the Principles of the Defense Buildup Program as demanded by the Americans, they share a consensus that defense buildup measures should continue to enjoy top priority among various Government measures.

A majority also agreed that defense-related expenses might very well exceed one per cent of GNP in the course of the buildup program. "GNP itself is variable," President Ryoichi Kawai of Komatsu Ltd. stated. "We should not take GNP as something absolute. It should be considered only as one of the yardsticks in formulating necessary defense policies." All the pollees maintained that we should not be concerned about holding down defense-related expenses to one per cent of GNP.

"The most important thing is what we should do about our defense," Chairman Sadakazu Shindo of Mitsubishi Electric Corp. stated. "The problem of expenses comes only after we have made a decision on this all-important problems."

Although some, like President Tsunesaburo Nishimura of Sumitomo Heavy Industries, stated that some ceiling was necessary for defense expenditures if the one-per-cent-of-GNP framework was removed, most, like Chairman Yagi of Shin Meiwa Industry, were of the belief that there was no possibility of defense outlays expanding uncontrollably even in the absence of pre-set limitations.

Technology exchange

As to technological assistance sought by the Americans, many defense industry leaders declared themselves in favor complying with the requests.

"As long as a great majority of our military technology originally came from the United States," announced Chairman Zenji Umeda of Kawasaki Heavy Industries, "we should comply with the Americans' requests." Many are more of less the same opinion as Umeda; they are for repaying the favors accorded.

Chairman Taiyu Kobayashi of Fujitsu, on the other hand, maintained that, if Japan remained only at the receiving end of technological exchanges with the Americans, it would sooner or later be cut off from the exchange list.

President Takashi Ishihara of Nissan Motor thought that Japan should go along with the Americans' requests in the belief that it was to the mutual good of the two nations to step up technological exchanges in communications equipment and electronic machinery, be they of a military nature or not.

"Joint research and development will be highly effective," concurred President Kazuo Maeda of Mitsui Engineering & Shipbuilding, "for the advancement of Japan's own technological standards."

Export controls

As to the existing three negative principles on arms exports, President Shoichi Saba of Toshiba Corp. stated that rules were too exacting as they cover such non-direct "weapons" as radar.

"If export controls are slackened vis-a-vis free world countries," President Kinoshita of Hitachi Shipbuilding & Engineering stated, "we would be able to make a considerable contribution to the overall strengthening of the free world's defense. Exports also will help reduce production costs and improve technological standards."

Defense industry leaders' attitude toward exports has apparently become more positive now that at the beginning of the current year when exports of gun barrels to the Republic of Korea by a special steel manufacturer touched off a great controversy. At that time, defense industry leaders maintained a very low profile.

Some, like President Tateno of Japan Steel Works, however, was very cautious about urging the Government to change the existing three principles at the present time, maintaining that exports of arms are only of secondary importance in the nation's defense industry policy.

Gakuji Moriya Interview

Tokyo THE JAPAN ECONOMIC JOURNAL in English No 971, 8 Sep 81 p 11

[Interview with Gakuji Moriya, chairman of Keidanren's Defense Production Committee, date and place not given]

[Text] Talks about Japan's defense capability have been going on heatedly ever since Washington called on Tokyo to upgrade its defense power, and many people believe that the Japanese defense industry is now in an excellent position to take full advantage of the nation's increasing awareness of the defense problem. At this important juncture, the Nihon Keizai Shimbun had an opportunity to talk with Gakuji Moriya, chairman of Keidanren's Defense Production Committee and concurrently advisor to Mitsubishi Heavy Industries, on a variety of defense matters. Excerpt of the interview follows.

Q: What are your opinions of the Americans' call for Japan to bolster its defense capability and of the Japanese Government's response to Washington?

Moriya: You have to make a clear distinction between the Government's defense policy and defense production itself in talking about any defense problems. What Japan should do about its defense is, in the final analysis, up to the Government. Every Japanese, however, has a right to discuss the problem and make his contribution to the Government's final decision. You should fully discuss whether the Americans' demands on Japan's defense power are really cogent or not, or whether Japan can or cannot follow Washington's demands if it really wants to.

Some talk about limiting defense-related expenses to certain percentages of GNP. Is their theory really right? Does the theory hold up in the face of the stark reality in the United States, the Soviet Union and EC? What is the reality in Switzerland, the very symbol of peaceful nations in the world, and Sweden, the country known for its considerate welfare measures? If the ratios of defense-related expenses in such nations are far higher than those of Japan against GNP, something must be wrong with Japan's policy.

Q: The United States is now seeking Japan's military technology in such fields as communications and electronics and is hoping for joint research and development. Do you think that Japan should comply with Washington's wishes?

Moriya: Prime Minister Suzuki confirmed when he met with President Reagan that relations between Tokyo and Washington constitute a full-bodied alliance. It is only natural for allies to cooperate with each other for promotion of science and technology. Although the line between military technologies and non-military technologies has never been quite clear, I believe that technology exchanges between private corporations on both sides of the Pacific should more be activated.

Q: The problem is the Government's three basic principles on arms exports, isn't it?

Moriya: We can understand the Government's stand when it says not to make arms shipments to the Communist countries, the countries specified by the United Nations and the countries engaged in international disputes. The trouble, however, is that it is not always clear what constitutes military equipment and what does not. We have to ask the Government whenever we face the slightest doubts.

Q: What action is the Defense Production Committee going to take from now on?

Moriya: For current fiscal year, we will place extra emphasis on our demand to increase the share of equipment in the nation's entire defense-related outlays.

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SCIENCE AND TECHNOLOGY

OBSERVATION ANALYSIS CENTER TO BE ESTABLISHED FOR RESOURCES SATELLITE USE

Tokyo THE JAPAN ECONOMIC JOURNAL in English Vol 19, No 971, 8 Sept 81 p 13

[Text] About 30 leading industrial corporations and banks are scheduled to set up a joint research foundation in Tokyo by the end of this month to analyze all sorts of information concerning earth resources to be obtained from the remote-sensing American Landsat series of satellite and Japan's first equivalent to be orbited by 1987 or 1988.

The proposed Resources Observation Analysis Center will be founded shortly after the September 15 meeting of the 11 sponsors — five oil exploration-development and 6 metal mining-smelting companies. So far, 27 companies have expressed intention to join the project to set up and operate the center on a semi-permanent basis.

The five oil exploration-development companies are Japan Petroleum Exploration Co., Teikoku Oil Co., Idemitsu Kosan Co., Indonesia Petroleum Ltd., and Arabian Oil Co.

The six metal mining-smelting companies are Nippon Mining Co., Mitsui Mining & Smelting Co., Mitsubishi Metal Corp., Sumitomo Metal Mining Co., Nittetsu Mining Co., and Dowa Mining Co.

The 16 others are Mitsui Mining Co. (coal mining), Toshiba Corp., Mitsubishi Electric Corp., Nippon Electric Co., Hitachi, Ltd., Fujitsu Ltd., and NAC Inc., all electric-electronic manufacturers, and nine big city-based major commercial banks.

Japan has been entirely dependent on three U.S. Landsat satellites orbited since 1972 for whatever information it wants on hidden underground and undersea natural resources in and around its territory as well as geological conditions and changes detectable only through remote sensing from space.

All such information comes from the satellites in photographic images digitized into numerical values requiring computerized analysis and synthesis.

Though having a few specialized computer systems to do such jobs, including that of Japan Petroleum Exploration Co., Japan is still way behind America in such analyzing technology.

The 11 sponsoring companies at the end of July thus decided to create such an industrial center of Japan's own as quickly as possible.

The proposed center is to start its research activities first by undertaking a job of developing Japan's own via-satellite remote resources sensing technology from the Ministry of International Trade & Industry under a ¥1 billion national budgetary appropriation the latter is seeking for fiscal 1982.

Besides gathering all available technical knowledge concerning analyzing of the Landsat-provided information, the center will also develop a new analytical method to match the information to be sent down from Japan's own resources satellite being planned by MITI together with the National Space Development Agency with a synthetic open-mouth type of radar to obtain images of earth resources through radar beams and their reflections.

Such a radar probing system is said to provide much clearer, better images that the Landsat's special cameras.

The joint research foundation is expected to pave the way for Japan's establishment of its own remote sensing technology.

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SCIENCE AND TECHNOLOGY

PLANT BUILDERS ASK IRAQ FOR WAR DAMAGES OF ¥40-50 BILLION

Tokyo JAPAN ECONOMIC JOURNAL in English Vol 19, No 971, 8 Sep 81 p 8

[Text] Japan's five industrial plant builders have filed with the Iraqi Government demands seeking payment of damages for losses they suffered following the outbreak of the Iran-Iraq War and ensuing suspension of construction work.

The five are Chiyoda Chemical Engineering & Construction Co., Kawasaki Heavy Industries, Ltd., Mitsubishi Heavy Industries, Ltd., Toyo Engineering Corp. and Niigata Engineering Co.

They have asked Iraq to compensate them for damages amounting to ¥40-¥50 billion, or 15 to 20 per cent of the original order values.

The five engineering firms have applied war clauses or/and force-majeure clauses in contracts to their overall demands for compensations, including those for many losses expected to arise until plants are completed.

The cases involved are nine contracts concluded from February through December, 1979 to construct oil refining, cement-making and other industrial plants on a full turnkey basis. (See table attached.)

Their combined value amounts to ¥260 billion.

Construction of those plants had been moving smoothly until September, 1980, when the Gulf War broke out, forcing the builders to cease to work.

Japanese industrial plant builders calling for Iraq to pay war damages

Plant	Contractors	Contract time	Contract value	Construction site
Oil-gas separation	Niigata Engineering (Marubeni)	Feb. 1979	¥5 billion	—
Cement	Kawasaki HI (Marubeni)	April	¥25 billion	Hit
Cement	Kawasaki HI (Marubeni)	June	¥20 billion	Hit
Cement	Kawasaki HI (Marubeni)	July	¥50 billion	Al-Tamim
LPG	Mitsubishi HI (Mitsubishi)	Sept.	¥28 billion	Kirkuk
Gas booster station	Mitsubishi HI (Mitsubishi)	Sept.	¥19 billion	Kirkuk
LPG and NGL	Toyo Engineering (Mitsui)	Oct.	¥15 billion	Kohr Al-Jubail
Oil refining	Chiyoda CE&C (Mitsubishi)	Oct.	¥65 billion	Beiji
NGL	Chiyoda CE&C (Mitsubishi)	Dec.	¥33 billion	North Rumaila

Note: Companies in parentheses are intermediary traders.

In April, this year, the Japanese constractors resumed construction, but they encountered another hurdle — inability to use Basra Port and the cost increases resulting from the change of the routes to transport supplies and equipment, and an accompanying spiral in personnel expenses.

While resuming construction, Kawasaki HI and some other companies calculated their monthly losses and requested Iraq to indemnify them for the damages. (Kawasaki HI, for example, demanded for ¥6 billion in compensations for losses it suffered until last June.)

The demands of the five firms are not the same as the progress of their jobs differs. However, they cite such factors as higher costs for equipment maintenance, ship demurrages, temporary return of workers to their home countries, interest rate burden, and losses caused by delayed construction and rescheduling of initial plant start-up as well as natural increases in personnel expenses and materials procuring costs.

Thus, Chiyoda CE&C and Kawasaki HI, which hold orders worth about ¥100 billion, want Iraq to pay ¥15-¥20 billion in damages, respectively, and Mitsubishi HI, ¥7.5-¥10 billion in damages against its ¥50 billion contracts.

Iraq's reaction to these Japanese demands, however, will be slow because the Iraqi channels of bargaining are split into three — Construction Industry Corp. of the Iraq Industry Ministry, State Organization for Oil Projects (SCOP), and Iraq National Oil Co. (INOC).

It will be not until a few months hence that full-fledged compensation talks will be held. Also, it seems that it will take a long time before all of the disputes are settled.

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SCIENCE AND TECHNOLOGY

MITSUBISHI, WESTINGHOUSE TO COLLABORATE IN HIGH TECHNOLOGIES

Tokyo JAPAN ECONOMIC JOURNAL in English Vol 19, No 971, 8 Sep 81 p 1

[Text] Mitsubishi Electric Corp. and Mitsubishi Heavy Industries, Ltd. will tighten their present technical cooperation relations with Westinghouse Electric Corp. of the U.S. and jointly engage in development of high technologies with it. They recently came to agreement on such an arrangement.

Industrial robots, semiconductors and new energy sources will be the major themes of the joint research and development project between Mitsubishi Electric and Westinghouse. Mitsubishi Electric, which already has been marketing welding robots, will tackle development of intelligent robots jointly with the American partner.

The two firms also will promote joint studies on very large-scale integrated circuits (VLSI). They already have inaugurated a project team for launching a joint VLSI manufacturing venture.

In the field of new energy sources, Mitsubishi Electric and Westinghouse will shortly start a joint study on effective utilization of solar energies as well as on new type atomic power reactors. They also are expected to exchange technical information on nuclear fusion.

These joint R&D projects will make Mitsubishi Electric an equal partner of Westinghouse in the true sense of the word, though it so far has tended to depend on the American firm's advanced techniques.

Mitsubishi Heavy Industries and Westinghouse have agreed jointly to develop an advanced pressurized water reactor (APWR) having a power output capacity of around 1.3 million kilowatts, a little larger than the conventional PWR.

Westinghouse also has agreed to help MHI develop a fast breeder reactor (FBR) by offering engineering data. In the future, the two firms will jointly develop commercial-scale FBRs.

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SCIENCE AND TECHNOLOGY

TRIPARTITE FUTURE COMPUTERS PROJECT WITH U.S.-EUROPE

Tokyo THE JAPAN ECONOMIC JOURNAL in English Vol 19, No 971, 8 Sep 81 p 9

[Text]

A Japan-U.S.-Europe tripartite project to jointly develop the so-called "fifth-generation computers" will be inaugurated next year as 15 leading American and European companies already have notified their intention to participate in the Japanese Government-proposed meeting of computer experts in Tokyo scheduled for late October.

The experts' meeting is expected to lay the ground for the planned 10-year international project, starting next April.

A fifth-generation computer, an advanced version of the present fourth-generation one, is a high-performance unit capable of "learning," "inference" and other functions that conventional computers cannot do.

Among the 15 participants are International Business Machines Corp., Sperry-Univac, Honeywell, NCR, Texas Instruments and Siemens. IBM's participation will give significance to the planned project as the world's largest computer builder already has made several breakthroughs in techniques to produce next-generation computers.

The Japanese Government has called for international cooperation to develop such high-performance computers as well as cooperation among the government, industry and scholars. Major reasons that has led the Japanese Government to propose the tripartite project are:

—Development costs will become too huge for a single company or a single country to meet.

—A joint tripartite project will prevent possible frictions over high technologies from developing among them.

—Basic studies on components for the fifth-generation computers have progressed to a considerable extent at governmental institutions in industrialized nations, and joint utilization of such studies will accelerate development of next-generation computers.

Other major overseas participants in the experts' meeting are Honeywell-CII of France, Nixdorf of West Germany, Dearborn Canada Computer of Canada and Computer Maintenance of India.

About 50 top-rate scholars and technicians of Japan, the U.S., Britain, France and West Germany also will attend the meeting and disclose their recent achievements.

Sources close to the Japanese Ministry of International Trade & Industry highly rated IBM's participation in the meeting as it so far has been developing techniques on its own.

Optimism is unwarranted, however. There are many problems to clear before fifth-generation computers are practicalized, such as possible disputes over patents and know-how on the fruits of the joint development project.

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SCIENCE AND TECHNOLOGY

DOMESTIC COMPUTER MAKERS UNABLE TO RETURN SUBSIDIES

Tokyo THE JAPAN ECONOMIC JOURNAL in English Vol 19, No 971, 8 Sep 81 p 9

[Text]

Profitability of Japanese computer makers is so low that they now find it difficult to repay before the March 31, 1982 deadline the subsidies they received from the Government in the early 1970s.

Fujitsu Limited, Hitachi, Ltd., Nippon Electric Co., Toshiba Corp., Mitsubishi Electric Corp. and Oki Electric Industry Co. have received a total of ¥57,470 million worth of subsidies for five years since fiscal 1972 for development of super high-performance computers.

Since around 1974, they have developed such medium- and large-size general-purpose computers as the M Series (the Fujitsu-Hitachi group), the ACOS Series (NEC-Toshiba) and the MELCOM/COSMO Series (Mitsubishi). Oki withdrew from the general-purpose computer field.

It was learned recently that none of the six Japanese computer builders has paid back the subsidies. They are required to repay the subsidies when they earn profits from sales of computers that they have developed on the subsidized projects. No repayment indicates that they are still unprofitable. This sharply contrasts their recent remarkable achievements in computer hardware technology and Fujitsu's outranking of IBM Japan Ltd. in sales to become the nation's largest computer maker.

The low profitability of Japanese computer makers is ascribed to their excessive price-cutting marketing competition and huge research and development costs. According to a survey of the Ministry of International Trade & Industry, the computer industry spends an average of 9.3 per cent of sales for R&D, far higher than that of other industries.

It will take some more time before the Japanese computer industry becomes profitable, a MITI official said.

CSO: 4120/1

SCIENCE AND TECHNOLOGY

FUTURE OF TRADE RELATIONSHIP BETWEEN JAPAN, USSR OVERVIEWED

Tokyo NIHON KEIZAI SHIMBUN in Japanese 31 Aug 81 p 3

[Interview with Masahiro Arakawa, Former Chief, USSR Office, Mitusbishi Corporation]

[Text] Starting with negotiations on equipment for the 13 billion dollar Yamburg natural gas project, trade relations between Japan, Western Europe and the United States and the USSR have reached a turning point. The U.S. has urged Japan and Western Europe to restrain East-West trade relations within the limits of the West's security. I asked Masahiro Arakawa, former chief, USSR Office, Mitsubishi Corporation (presently with the machinery department, Mitsubishi Corporation) what will happen with Japan-Soviet trade relations. (The reporter is Hideo Tamura, economics department, Tokyo main office).

Course of East-West Trade Relations

[Question] The Reagan administration is trying to regulate East-West trade relations from the standpoint of security, isn't it?

Logic of Strength in the Background

[Answer] Certainly the Reagan administration is assuming a strong posture, but I think that is a strong principle but we should not necessarily be pessimistic about the actual flow of the economy. The former Carter administration sought to clamp down on exports to the Soviets on the grounds of human rights, but with the Reagan administration's methods, it is easier for the USSR to respond to negotiations. The USSR has traditionally believed that might makes right and if their opponent shows strength, the USSR will understand and ask for negotiations. The logic of strength is even behind the removal of the U.S. embargo on grain exports. It is a mistake to be under the simplistic impression that both heads and tails are the same thing.

If the USSR is prepared to make some kind of concessions, the U.S. will also compromise. A good example of that is the authorization for the Caterpillar Company to export to the USSR pipe laying equipment for the Yamburg natural gas project. So long as the U.S. makes a principle of tying trade with the

Soviets to security, it will strongly oppose having West Germany and others depend on the USSR for 15-30 percent of their natural gas supplies. However, the U.S. has approved the pipe laying equipment under the pretext that it is unrelated to Yamburg. No one can guarantee that the pipe laying equipment which can be freely moved will not be used at Yamburg.

[Question] Can the Western allied nations avoid the unbending principle of the U.S.?

[Answer] The U.S. is requesting West Germany's reconsideration of the introduction of natural gas from Yamburg into West Germany, using substitute energy supplies as the condition, but West Germany is holding firm. Ruhr Gas, the gas company, counterargues that even if the USSR applies the political pressure of completely cutting off natural gas supplies, the national interest will not be harmed. It has considered countermeasures with such means as changing raw materials or using on-hand supplies so that even in an emergency situation there will be no problem for large consumers.

West Germany even depends on Libya for 4 percent of its total energy. It is argued which is more dangerous, Libya or the USSR, and as long as the U.S. does not propose a better alternative, I do not think West Germany will give up the introduction of gas from the USSR. Because the Yamburg project is such a large scale project, the plan is apt to be delayed; negotiations will move ahead in installments.

[Question] The U.S. is pressing Japan and Western Europe to tighten controls on exports of high level technology. What about that effect?

Western Unity Impossible on "Technology"

[Answer] In the case of my company and Mitsubishi Heavy Industries, Ltd., as a result of economic sanctions against the USSR following its invasion of Afghanistan we could not export second recovery equipment for oil fields to the USSR and so France finally did. Since the basic technology was introduced from the U.S., we cannot export without authorization from the U.S. government. The U.S. holds much of the high technology, and the U.S. where those with the technology move freely has historically been compised of people of European descent, and so there are limits to how much the outflow of technology to Europe can be held in check. However, U.S. technology will not be introduced into Japan unless we make the customary contract for technology introduction. On that point, France has been successful. Western unity is impossible, isn't it?

It has recently become difficult to export items that until now had been approved for export to the USSR even though they were on the COCOM embargo list. Three-dimensional machine tools are an example. We are having a difficult time changing our methods and the like in order to get approval.

[Question] Isn't the Soviet government quite dissatisfied with Japan's trade policies towards the USSR?

[Answer] Having been asked many times last year to meet with Soviet officials of the Ministry of Foreign Trade, I went to Moscow. At that time, one of the directors said: "we used to think Japan was the Soviet Union's number one partner, but haven't you been outstripped by West Germany, France and England?" I explained to him that Japan's exports to the U.S. account for more than one-fourth of all exports, and the Soviet director smiled when I presented him with a U.S. publication's special edition on trade friction with Japan.

The foundation of USSR trade policies is driving hard bargains to purchase products from the West cheaply. To do this, it is necessary to set Japan, the East, against Western Europe. Even in the Yamburg talks, the Soviet Union brought Japan a deal of 3 billion dollars, but with the exception of Daikei Kokan Company, most of the other materails can be sufficiently supplied by Europe. Clearly there are items which would not have to be purchased from Japan. Likewise, with Yamburg as the bait, its aim is to get financing from the Export-Import Bank of Japan. I understand that the amount of orders Japanese enterprises can receive in the Yamburg negotiations is 1.4-1.5 billion dollars.

[Question] Talks on plants other than Yamburg have made themselves scarce, haven't they?

[Answer] That't right. This is not because the political situation or the economic sanctions against the USSR are obstacles; the major reason is that the building of the Soviet economy has arrived at a turning point. Until now it has purchased steel, fertilizer and chemical plants. The Soviets have done their best, but there are plants here and there which are still not in operation. A film plant which Mitsubishi contracted for in cooperation with Konishiroku Photo Industry Co., Ltd. has remained unopened for more than a year. In order to imporve the operating efficiency of these plants, the USSR put major emphasis on providing completely such basics as transportation and parts supplies. Therefore, talks with the USSR on plants have all grown smaller. Only energy related plants are the exception. the USSR has to export energy resources in order to gain foreign currency. When inflation is taken into consideration in Japan's exports to the USSR, they remain almost at the same level as last year.

[Question] It is said that one of the USSR's economic weaknesses is its foreign currency situation.

Grain Shortage Cannot Be Solved

[Answer] The Soviet Union's trade revenues with OECD countries were in the black by 800 million dollars. Conversely, the USSR's trade with the West was constantly in the red. The cost of grain imports due to large amounts of comparatively expensive Argentine wheat because of the U.S. grain embargo an a bad harvest is supposed to be an additional 2-3 billion dollars, but I haven't heard that they have launched into selling their reserves because of it. A major reason is that foreign currency income has increased with the steep rise in energy prices. Rather, isn't the shortage of funds in the

country the question confronting them? Even though the USSR's financial crisis is not as great as Japan's, budgetary deficits are conspicuous with the delay in plant operations.

Soviet agriculture is limited to agriculture in the north and dry Central Asia. A good or bad harvest clearly depends on the amount of rainfall. No matter how much they try, the grain shortage will not be solved. The pattern of exporting energy resources and purchasing grain and industrial products from the West will still continue. There are reasons for pointing out that if the U.S. places a total embargo on ultra-modern energy technology, the USSR will be immediately driven into a corner and would plan to advance into the Middle East; and even the Reagan administration cannot completely stop exports of oil exploration technology to the Soviet Union.

Comment

Since the Soviet invasion of Afghanistan in December 1979, Japan's exports to the USSR have levelled off. With the economic sanctions against the USSR since January 1980, plant exports have been curbed, and last fall electromagnetic steel sheet plants and the like were snatched away by France. Japan which started late in the Yamburg talks is playing second fiddle to Europe.

Naturally, dissatisfaction is expressed in industrial circles. However, Mr. Arakawa who was in the forefront of Soviet business until this past August is quite unperturbed. He thinks that the"Reagan administration's strong posture toward the USSR aims at gaining concessions politically" and he sees the possibility of a thaw in U.S.-Soviet trade relations. He says that the progress of talks between the Japanese government and the USSR "should not be hurried and will be meaningless unless there is a clear purpose." The experience of a businessman seems to be extremely different than that of government officials.

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SCIENCE AND TECHNOLOGY

ELECTROMAGNETIC PROPULSION METHODS DESCRIBED

Tokyo DENSHI GIJUTSU SOGO KENKYUSHO IHO in Japanese Vol 41 No 6, 1977 pp 67-76

[Article by Katsuo Nishiyama, Masaomi Kimura, Energy Dept., Energy Conversion Research Room; and Takuma Homma Energy Dept., Energy Conversion Research Room, Chief, Ph.D. in Engineering. Article received 21 April 1977]

[Text] 1. Preface

As the development of ocean progresses, it is believed that the use of marine vehicles operating at great depths would be inevitable. If so, the application of conventional propulsion method to such vessels would create several problems including the maintenance of airtightness in the transmission section, cavitation created around the propellers, noise from power transmission devices and propellers, the decline in the propulsion efficiency, etc. For this reason, since around 1960, when [the study of] electromagnetic hydromechanics was [just] beginning to emerge, there began a research in the electromagnetic propulsion method which, based on the observation that seawater conducts electricity, would create propulsion by adding electromagnetic forces to the water. The major feature of this method was the elimination of solid movable parts unavoidable in the propeller method; its advantages include the ability to maintain [better] airtight conditions, easier handling, and low noise level. The electromagnetic propulsion methods proposed to date can be classified by categories of working fluids as shown in Table 1. Based on this table, we shall discuss the principles involved in each method and the performance of each as a source of propulsion, in particular, the method using the liquid metals.

2. Seawater Method

2.1 Induction-type Propulsion

In 1962, Phillips of the United States proposed an induction-type electromagnetic jet propulsion method shown in Figures 1 and 2, and published a detailed analysis of its characteristics.[1] Figure 1 shows how symmetrically moving magnetic field is created along the external walls of a vessel; seawater is jetted out by the reciprocal action of induction current created by the moving magnetic field and the field itself. Figure 2 shows how seawater can be jetted out through the ducts by creating concentric cylindrical shells outside

Table 1. Classification of Electromagnetic Propulsion Methods

Working fluid	Working fluid thrust method	Channel method and yes or no of experiment	Sources
Seawater	Induction method	Internal, no External, no	1) 1)
	Electric conduction method	Internal, yes External, no	2)3)7)8) 4) - 6)
Liquid metal	Induction method	Internal, no	9) - 11)
	Electric conduction method	Internal, yes	13)
Solid-liquid 2-phase flow	Magnetic suction method	Internal, no	14)

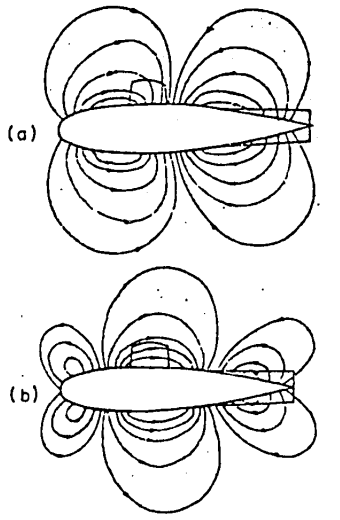


Figure 1. Distribution of Lines of Magnetic Forces of the Induction-type External Magnetic Field Electromagnetic Jet Propulsion System Proposed by Phillips
(Source: Bibliography 1)

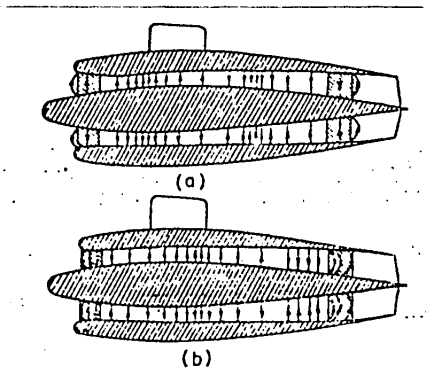


Figure 2. Structure of Induction-type Electromagnetic Jet Propulsion System and Flux Distribution. There is a 1/4 cycle phase difference between (a) and (b)
(Source: Bibliography 1)

the vessel, and by forming magnetic circuits using coils on both the body of the vessel and the external shells so as to provide for a concentration of magnetic flux. Concerning these methods, Phillips has concluded that the maximum value of efficiency is 8 to 10 percent.

2.2 Electrical Conduction-type Propulsion

In 1963, Doragh announced a pump jet method using superconducting magnets as shown in Figure 3.[3] Figure 4 shows the relationship between speed and efficiency of a vessel with a displacement of 2,000 t, channel length of 15.24m, channel area of 6.98m^2, ratio of channel area to seawater input area (diffusion ratio) 1.02, and ratio of [wave area?] to seawater output area (jet ratio) 1.49. Also, Way proposed a structure which enlarges the range of electromagnetic action as shown in Figure 5.[4-6] The sides of a vessel are wired with superconductors through which currents of opposite direction flow alternately and electrodes are attached to the outside of wiring. Those with two electrodes are called two poles, those with four electrodes, four poles. The two-pole type is more efficient, but in order to minimize the effect of magnetic field inside the vessel, more than six poles is ideal. The distribution of the lines of electric forces and lines of magnetic forces for a two-pole type

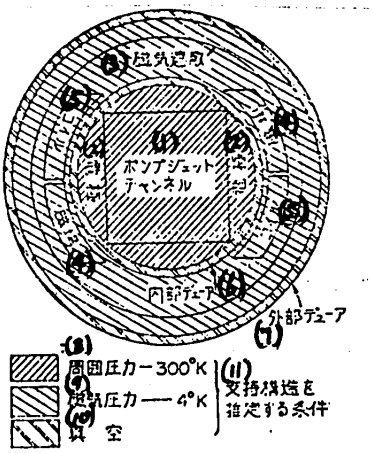


Figure 3. General Diagram of MHD Pump Jet (Source: Bibliography 3)

Key:
(1) Pump jet channel
(2) Electrode
(3) Magnetic shelter
(4) Magnetic field
(5) Coil
(6) Internal Dewar
(7) External Dewar
(8) Surrounding pressure--300°K
(9) Magnetic pressure--4°K
(10) Vacuum
(11) Conditions for assuming the supportive structure

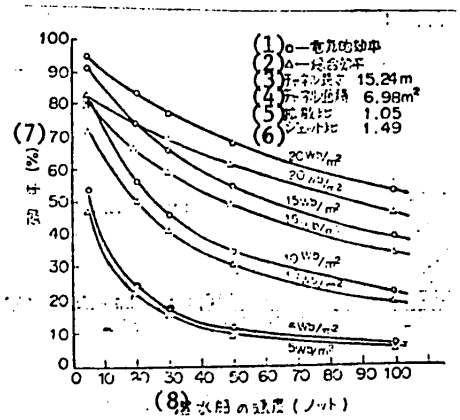
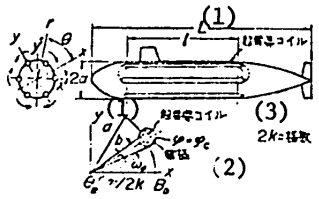


Figure 4. Relationship Between Ship Speed and Efficiency Based on Flux Density as Parameter (Source: Bibliography 3)

Key:
(1) Electric efficiency
(2) Comprehensive efficiency
(3) Channel length
(4) Channel area
(5) Diffusion ratio
(6) Jet ratio
(7) Efficiency (percent)
(8) Speed of submarine (knots)



Key:
(1) Superconducting coil
(2) Electrode
(3) 2K=number of poles

Figure 5. Electric Conducting External Magnetic Field-type Six Poles of (K=3) of Electromagnetic Jet Propulsion System for a Large Submarine Tanker Proposed by Way (Source: Bibliography 6)

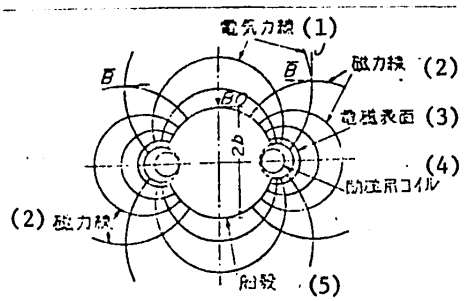


Figure 6. Distribution of Lines of Magnetic and Electric Forces in the Case of Two Poles (Source: Bibliography 5)

Key:
(1) Lines of electric force
(2) Lines of magnetic force
(3) Electromagnetic surface
(4) Excitation coil
(5) Ship hull

are shown in Figure 6. Table 2 shows the results of calculation on the propulsion characteristics of a submarine tanker with a displacement of 2,500 tons, total length of 151.2(m), body radius of 8.64(m), total submerged area of 6,840(m^2), drag coefficient of 0.00156, and length of electrode, 75.6(m). When various problems concerning superconducting magnets (e.g., cable support method, compact pole low temperature system, etc) are solved from these results, we can expect the realization of an electromagnetic jet propulsion vessel. In 1966, in order to confirm the propulsion principle shown in Figure 5, Way and others built and tested an experimental electromagnetic propulsion ship of the size shown in Figure 7. As a result, it was reported that the ship traveled at a speed of about 25 (cm/sec) when the exciting current was at 140 (Amp) and the current between electrodes at 120 (Amp). Furthermore, Kimura and others built their own experimental four-pole type with an external magnetic field and a two-pole type with an internal channel; they are studying the propulsion

Table 2. Propulsion Characteristics of a 25,000 Ton Tanker

Speed u (m/s)	5		10		15	
Thrust F x 10^{-3} (N)	13.10		520.1		1,172	
Effective output P_T (kw)	650		5,201		17,600	
Number of poles	4	6	4	6	4	6
Electric efficiency ηe	0.928	0.920	0.868	0.852	0.813	0.793
Input P_E (kw)	700	707	5,990	6,110	21,650	22,200
Voltage between electrodes(V)	143	105	305	227	490	366
Electrode current 21 (A)	2,445	2,244	9,810	8,975	22,100	20,220

Note: Bcr = 7.6Wb/m^2 for 4 poles
Bcr = 7Wb/m^2 for 6 poles

(Source: Bibliography 6)

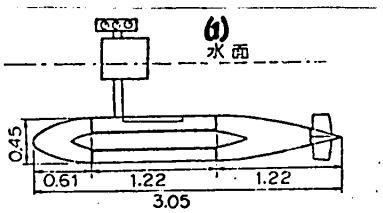


Figure 7. A Model for a 2-Pole Electromagnetic Submarine Designed by Way

Key: (1) Water surface

performances efficiency using strong magnetic fields, Minakawa and Miyake built and tested a pump jet propulsion ship equipped with a mechanism to cool saddle-shaped copper coils to liquid nitrogen temperatures.[8] Table 3 compares the results of experiments between Minakawa's model and others.

3. Liquid Metal System

From above it is apparent that the use of superconducting magnet is indispensable in order to realize the method which uses seawater. In such a case, however, the [propulsion] system must be of large scale, which is inappropriate for smaller submarine research vessels with displacements of less than 10 tons. For this reason, a conceivable alternative would be to use a medium with higher electric conductivity, such as liquid metals, as a working fluid to replace seawater; this will reduce the size of the propulsion mechanism.

Table 3. Comparisons of Characteristics of Electromagnetic Propulsion Systems

Item	1967 University of California	1970 Electrotechnical Laboratory	1971 Kobe University of Mercantile Marine
Method	External magnetic type	Internal magnetic type	Low temperature internal magnetic type
Total length of ship	3.0m	1.24m	1.10m
Diameter of ship	0.45(2b)m	0.42/0.22(=d)m	0.38/0.11(=d)m
Number of coils	402	300	1,000
Voltage	30V (=$2V_e$)	45V	48V
Exciting current	140A	47A	29A
Pole current	120A	172A	110A
Speed	0.27m/sec Underwater	0.08m/sec Tank	0.04m/sec Underwater
Magnetic field	0.015wb/m^2	0.012wb/m^2	0.18wb/m^2
Efficiency	1 x 10^{-4}	4.7 x 10^{-5}	1.6 x 10^{-5}

3.1. Induction-type Propulsion Vessel

Neuringer and his group have proposed a cylindrical compressor shown in Figure 8 and have been conducting theoretical studies of its electromagnetic action. To explain the functional principle [of this compressor], we refer to Figure 9. As the Figure shows, when N-S magnet moves in the direction of Z at a speed U, current (density) $j\theta = -\sigma UBr$ runs through the coil placed in the magnetic field. In this case, however, the magnetic field, in relation to the axial, has only the axial directional component Bz and radius directional component Br. At this point, the electromagnetic force arising in the coil can be expressed from $\vec{F} = \vec{j}x\vec{B}$ to $\vec{F} = \sigma UBr^2\vec{Z} - \sigma UBrBzr$ per unit volume. In other words, we see that the coil always receives a positive force in the direction of the axial, but a force which varies depending on the code of the magnetic field in the direction of the radius. Now, if the coil is replaced by the conductive fluid (working fluid) as shown in Figure 8, the force produced within the working fluid will transform the surface of the membrane, since the fluid is enclosed in the diaphragm which is composed of flexible membrane.

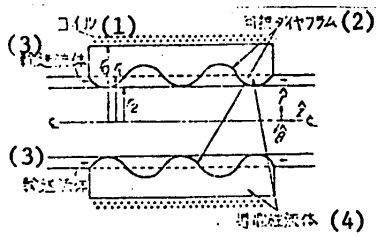


Figure 8. General Diagram of a Cylindrical Induction Compressor (Source: Bibliography 9)

Key:
(1) Coil
(2) Flexible diaphragm
(3) Transport fluid
(4) Conducting fluid

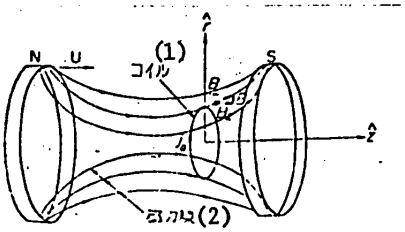


Figure 9. General Diagram of Electromagnetic Induction Produced Within a Stationary Circular Coil by Magnetic Field of Symmetrical Axis of Activated N-S Magnet (Source: Bibliography 9)

Key:
(1) Coil
(2) Lines of magnetic force

If, at this point, the magnetic field is a moving magnetic field as shown in Figure 10, the transformation of the flexible membrane will take the form of a progressing sine curve and the fluid between r_1 and r_2 will be pushed toward the direction of Z by the action of the membrane. As a result, a continuous pumping will take place. If we let the diaphragm in Figure 8 to be a cylinder with an outer diameter of 2 r_0 and an inner diameter of 2 r_1 and then seek the electromagnetic force Fz per unit volume produced within the working fluid, the force, in the case of $Kr_1 >> 1$, based on the following assumptions.---
1) the average speed of the working fluid in the direction of Z is zero (U=0),
2) the transport fluid is nonmagnetic and of low conductivity, and
3) the pressure incline produced within the transport fluid is equal to the electromagnetic force (F_2) calculated when the diaphragm is at its position of equalibrium ($r=r_1$)---it will be expressed as below:

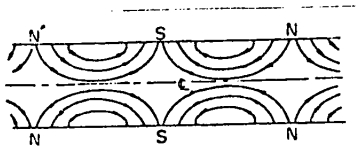


Figure 10. Distribution of Moving Magnetic Field Within a Cylindrical Induction Compressor

$$F_z \sim \frac{\mu_0 (NI)^2}{r_0} \left\{ \frac{1}{\left(\frac{r_1}{r_0}\right)\left(1-\frac{r_1}{r_0}\right)} \right\} G_1(R_m,\ Kh)$$

$$(r=r_1) G_1(R_m, Kh) = *$$

$$* \frac{Kh\ R_m \exp\left\{-Kh\left[2+2(R_m^2+1)^{\frac{1}{2}}\right]^{\frac{1}{2}}\right\}}{\left\{\frac{1}{2}\left[2+2(R_m^2+1)^{\frac{1}{2}}\right]^{\frac{1}{2}}+1\right\}^2 + \frac{R_m^2}{2+2(R_m^2+1)^{\frac{1}{2}}}}$$

Here, K represents the number of moving waves with $K = \omega/U$ (ω: angular frequency); NI, ampere turns per unit length; r_0, outer radius of the compressor; h, thickness of the tube section containing the working fluid, with $h = r_0 - r_1$; Rm, magnetic Reynolds number, with $Rm = \mu_0 \sigma \omega / K^2$; μ_0, permeability of free space; o, conductivity of working fluid. From the F_z equation, we see that electromagnetic force is proportionate to G_1; therefore, at Rm and Kh, where G_1 reaches the maximum value, F_z becomes the greatest. When we seek Rm and Kh, Rm = 4.120 and Kh = 0.309; thus, $G_1 max = 0.0553$. Figure 11 shows the relationship between G_1 and Rm, with Kh as the parameter. Based on these results, Neuringer and others have been studying the performance of this compressor as a marine propulsion equipment. According to their results, when the ratio of the length to the diameter of the ship is 10:1, when the drag coefficiency based on submerged area is 0.003, when the length of the compressor is 1/2 the total ship length, and when the thickness of the tube section of the working fluid and that of the tube section of the fluid which is being transported are equal, ships with total length of 114.6m and 5.33m would have a 90 percent jet coefficiency ($2/1 + (u_1/u)$; u_1, speed of jetted fluid; u, speed of ship) and travel at 30 knots under the following conditions. Figure 12 shows the relationship between the speed of the ship (u) and speed of the moving wave (U), with depth (d) from the sea surface to the ship as a parameter. However, this is based on the calculation that the critical tolerance pressure level of the cavitation at the entrance of the compressor is 0 (kg/cm^2). From this figure, we see that when a ship is traveling at a speed of 30 knots at the depth of 305m, the speed at which magnetic field can travel without producing cavitation must be below 80m/sec. Figure 13 shows the relationship between the magnetic Reynolds number (Rm) and the moving wave frequency (r_0) needed to obtain a minimum of magnetic field. Under the condition found in the figure, it can be seen that r_0 is below 100 Hz and that it is in inverse proportion to the dimensions of the ship. Also, the relationship between

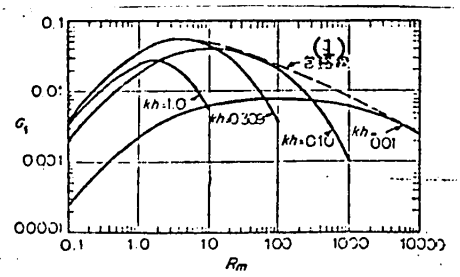


Figure 11. Relationship Between Dimensionless Axis Directional Force and Magnetic Reynolds Number (Source: Bibliography 10)

Key: (1) Envelope

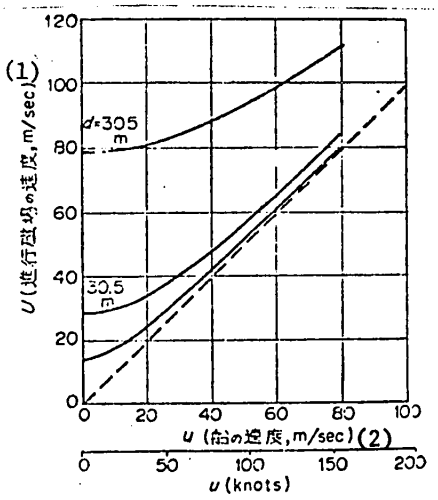


Figure 12. Relationship Between Ship's Speed and the Speed of Moving Magnetic Field With the Depth of the Sea Below the Ship as Parameter (Source: Bibliography 10)

Key:
(1) U (Speed of moving magnetic field, m/sec)
(2) u (Speed of ship, m/sec)

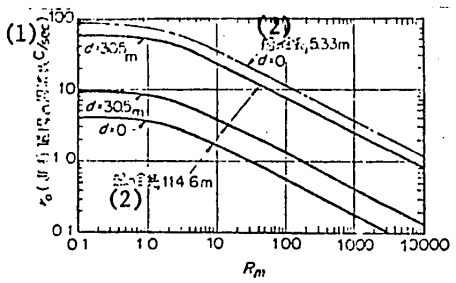


Figure 13. Relationship Between Magnetic Reynolds Number Satisfying the Conditions Which Minimize the Magnetic Field and Frequency of Moving Magnetic Field, Based on the Total Length and Depth of Sea Below the Ship as Parameters (Source: Bibliography 10)

Key:
(1) v_0 (Frequency of moving magnetic field C/sec)
(2) Total length of ship

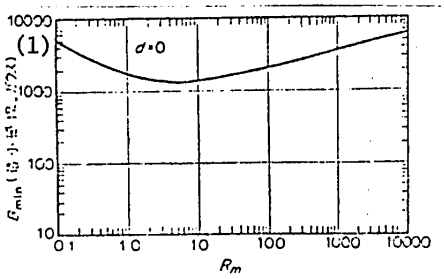


Figure 14. Relationship of Magnetic Reynolds and Minimum Magnetic Field When the Ship Is Traveling on Surface (Source: Bibliography 10)

Key:
(1) B_{min} (minimum magnetic field, gauss)

Rm and minimum magnetic flux density, B_{min}, is as shown in Figure 14; when Rm = 4.120, B_{min} must be 0.144 (Wb/m^2). It is conjectured that B_{min} should be about 0.1 (Wb/m^2) throughout a considerably wide range of Rm. The relationship between Rm and electric conductivity of the working fluid is as shown in Figure 15. We can see that by using lithium for smaller ships with total length of 5.33 (m), Rm will approach 4.120. Figure 16 shows the relationship between electrical coefficiency (ηe) and dimensionless value r; r is expressed as $r = kh\,[2+2(Rm^2 + 1)^{\frac{1}{2}}]^{\frac{1}{2}}$; when Rm = 4.120, kh = 0.309, then r = 1. From above, it is assumed that a ship with a total length of 5.33m, magnetic flux density of approximately $0.1Wb/m^2$, moving wave frequency of 50Hz, and lithium as working

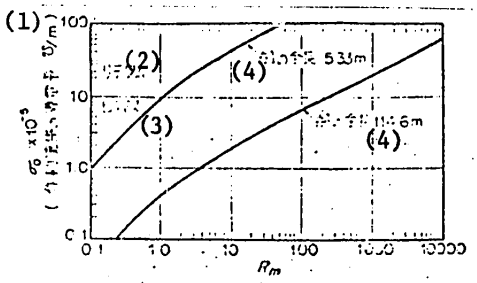


Figure 15. Relationship Between Conductivity of Working Fluid and Magnetic Reynolds Number, Which Satisfies the Conditions Minimizing the Magnetic Field, With the Total Length of the Ship as Parameter (Source: Bibliography 10)

Key:
(1) (Conductivity of working fluid ℧/m)
(2) Lithium
(3) Bismuth
(4) Total length of ship

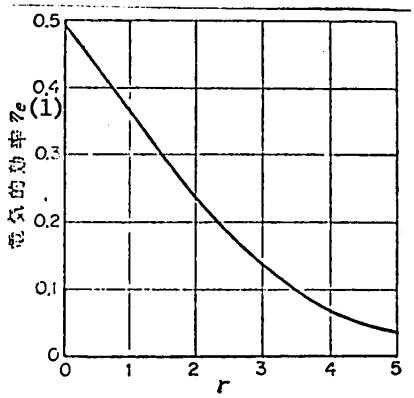


Figure 16. Relationship Between Electricial Efficiency and Dimensionless γ (Source: Bibliography 10)

Key: (1) Electrical efficiency ηe

fluid, will have a 33 percent efficiency and travel at 30 knots. Hiwever, since the melting point of lithium is 179°C, there are problems with respect to energy sources for liquifying lithium and membrane materials. For this reason, mercury may be substituted; but, although the problems of energy source and membrane may be solved, this will reduce the electrical conductivity by 10-fold and thrust will drop by 2.6 times and the speed will fall below 30 knots. Therefore, in order to use mercury as a working fluid and maintain the speed of 30 knots, we must increase the frequency by 10 times or magnetic flux density by 1.6 times. Moreover, the calculation in the above study is done on the supposition that the entire peristaltic motion energy of the membrane is converted to the motion energy of the fluid being transported. Therefore, let us briefly examine the characteristics of the peristaltic pump. Shapiro and others have been conducting a study

of peristaltic pump with long wavelength at low Reynolds numbers.[12] According to their study, the relationship between pressure and flux based on the assumed two-dimensional plane model and the pump efficiency (E) are as follows:

$$\frac{a^2}{\mu C\lambda}\Delta p_\lambda = \frac{3}{2}\frac{\phi^2}{(1-\phi^2)^{\frac{3}{2}}}\left[3-\frac{2+\phi^2}{\phi}\theta\right]$$

$$E=\frac{(\theta/\theta_0)(1-\theta/\theta_0)}{\frac{(1+2\phi^2)(2+\phi^2)}{9\phi^2}-\frac{\theta}{\theta_0}},\quad \theta_0=\frac{3\phi}{2+\phi^2}$$

Here, Δp, represents pressure per unit wavelength; $\theta = \bar{Q}/bC$; $\bar{Q}$, average flux per cycle; C, speed of peristaltic motion; b, amplitude; a, the position of membrane from the central axis when b = 0; λ, wavelength, μ, coefficient of viscosity; $\phi = b/a$. In addition, in the case of axial symmetry model, the relationship between pressure and flux as well as pump efficiency are as follows:

$$\frac{a^2}{4\mu c\lambda}\Delta p_\lambda = *$$

$$*\frac{8\phi^2\left(1-\frac{1}{16}\phi^2\right)-4\phi\left(1-\frac{1}{4}\phi\right)\left(1+\frac{3}{2}\phi^2\right)\theta}{(1-\phi^2)^{\frac{3}{2}}}$$

$$E=\frac{(\theta/\theta_0)\{1-(\theta/\theta_0)\}}{A(\phi)-(\theta/\theta_0)}$$

but,

$$A(\phi)=\frac{4+6\phi^2}{\phi^4(16-\phi^2)^2}*$$

$$*\left[4+4(1-\phi^2)^{\frac{1}{2}}+10\phi^2+7\phi^4+\frac{3}{2}\phi^6\right]$$

$$\theta_0=\frac{\phi(4+\phi)}{2+3\phi^2},\quad \theta=\frac{\bar{Q}}{\pi a^2 C\left(2\phi-\frac{1}{2}\phi^2\right)}$$

Figure 17 shows the relationship between dimensionless flux and pump efficiency. From the figure we can assume that, despite the relatively narrow range, efficiency can be raised considerably by expanding the amplitude. Shapiro and others have compared the results of their analysis with Latham's experimental results. Figure 18 is a simple diagram of Latham's experimental apparatus. The test tube is of 1.3 (mm) thick transparent vinyl chloride; at an average position, it is in the shape of a rectangle, 63.5 x 7.6 (mm). The fundamental wave multiplied by integers, approaching the sine curve, is produced by adjusting 32 pairs of fingers attached to the rotary ring. Figure 19 shows the test results in the case of 4-fold high waves at $\phi = 1/3$; the vertical axis shows the measured pressure value ($\Delta p\lambda$), made dimensionless by the pressure added at the time of zero flux. From this figure, we observe that when the Reynolds numbers are within the range of R < 0.2, theoretical and experimental results agree well; however,

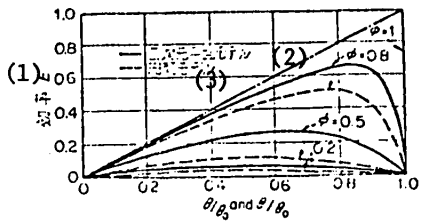


Figure 17. Relationship Between Efficiency and Flux With Amplitude Ratio as Parameter (Source: Bibliography 12)

Key:
(1) Efficiency
(2) Two-dimensional plane model
(3) Cylinder model

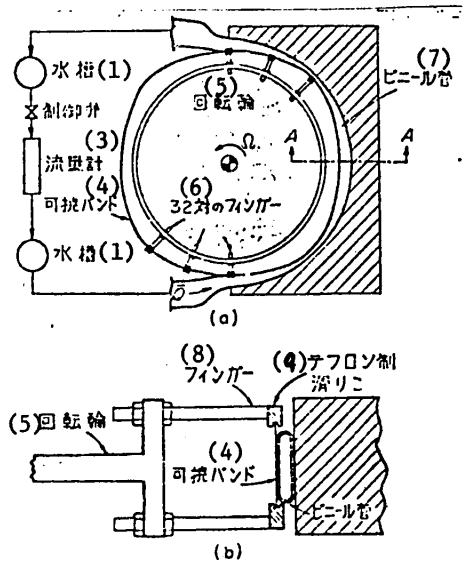


Figure 18. General Diagram of Testing Device
(a) plane; (b) details of cross section A-A
(Source: Bibliography 12)

Key:
(1) Tank
(2) Control valve
(3) Fluxmeter
(4) Flexible band
(5) Rotary ring
(6) 32 pairs of fingers
(7) Vinyl tube
(8) Finger
(9) Teflon slider

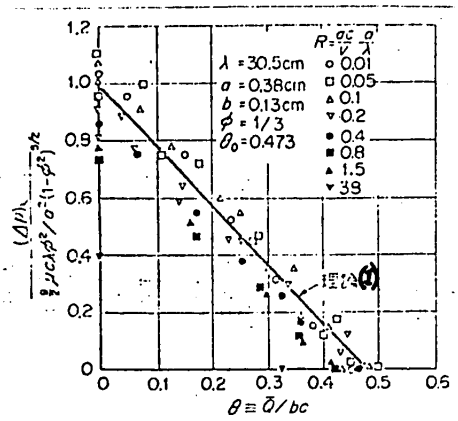


Figure 19. Comparison Between Theoretical and Experimental Values (Source: Bibliography 12)

Key: (1) Theoretical

within the range of R > 0.2, the two do not agree and the performance of the pump declines. Also, when R = 38, we assume that the performance of the pump will decline radically due to effects of inertia. Before Neuringer's induction-type electromagnetic compressor can be used as a propulsion mechanism, it is necessary to study the above-mentioned characteristics of the peristaltic motion pump and the problems attached to the working fluid.

3.2 Conduction-type Propulsion

Homma and Nishiyama have proposed a method using the action of working fluid within the U-shape tube and the resonance phenomenon of impressed electromagnetic force as illustrated in Figure 20.[13] This is an electric conduction system which requires magnets and electrodes, and its pump principle is same as that of dual alternating pump. Namely, as the figure shows, the electromagnetic force flows clockwise and, when the liquid column moves in the same direction by the same force, the pressure at valves 3 and 4 increases, allowing one directional valve 4 to open and seawater to flow out in the direction shown in the figure. Also, the pressures at valves 1 and 2 will decrease, allowing valve 1 to open and seawater to flow in. When the liquid column fully rises along one of the two sides of the U-shape tube and current from the battery is reversed by a DC-AC inverter, the reverse action will take place; i.e., the seawater will flow in and out through the valves 2 and 3, and continuous pumping action can take place. The action equation of the working fluid in this method is expressed as follows:

$$m \frac{d^2x}{dt^2} + 2\ pgsx + pf = P-T$$

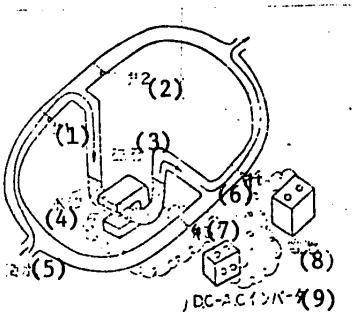


Figure 20. General Diagram of Electric Conducting Propulsion System Using the Action of the Fluid Column Within the U-shape Tube and the Resonance Phenomenon of Electromagnetic Force (Source: Bibliography 13)

Key:
(1) Valve 1
(2) Valve 2
(3) Magnet
(4) Mercury
(5) Seawater
(6) Valve 4
(7) Valve 3
(8) Battery
(9) DC-AC inverter

In the above equation, the first member of the left side of the equation represents inertia; the second, restoring force; the third, loss in flow. The first member of the right side represents input magnetic force; the second, thrust force. In order to examine the qualitative characteristics of thrust force of this method, let us suppose that $pf = C\frac{dx}{dt}$, $T = K\frac{dx}{dt}$, $P = \sigma(E-B\frac{dx}{dt})BV$, $E = E_0 \sin \omega t$. But E will stand for electric field; B, magnetic flux density; S, tube cross section area; V, volume of impressed electromagnetic force; σ, conductivity; pg, specific gravity. Based on the above supposition, our attempt to solve the action equation and find the output ratio (r) against maximum output and its efficiency (η) would be as follows:

$$r = 4\left(\frac{k}{\sigma B^2 V}\right)\frac{1+\frac{C}{\sigma B^2 V}}{\left(1+\frac{k}{\sigma B^2 V}+\frac{C}{\sigma B^2 V}\right)^2}$$

$$r = 1/(1+C/k)(1+k/\sigma B^2 V + C/\sigma B^2 V)$$

and $k/\sigma B^2 V$ where efficiency becomes maximum would be

$$k/\sigma B^2 V = \sqrt{\frac{C}{\sigma B^2 V}\left(1+\frac{C}{\sigma B^2 V}\right)}$$

In addition, the ratio of maximum output-- <Pout> max--each at C to the maximum output at C = 0, or <Pout> max, will be $(1 + C/\sigma B^2V)^{-1}$; <Pout> max will move to the point where $\sigma B^2V = 1+C/\sigma B^2V$. Figure 21 shows efficiency rate and the relationship between output and load, using the coefficiency of loss in flow as the parameter. The following is assumed from the diagram: a) Efficiency and output decrease gradually after passing their respective maximum points; b) the point of maximum efficiency is on the side of low load rather than on the maximum output point, but with the increase in the loss of flow, both points approach one another; c) the maximum output point exists where the load is greater than the electromagnetic force created by reverse electric force; d) the loss in flow greatly decreases efficiency and output. Figure 22 shows the experimental results of a simple electromagnetic pump system. (The length of electrodes is longer than that of magnetic poles, and no consideration is given to decrease the loss in flow.) From the figure, we see that the efficiency reaches its maximum when output is relatively small and that it decreases with the increase in output. Also, it is acknowledged that the point of maximum efficiency moves toward the direction of larger outputs as the speed of the alternating action of the mercury column increases. From the above qualitative analysis and experiment, further studies must be made of 1) quantitative indication method for each member of the action equation of the liquid column and 2) the most appropriate shape for the cross section of the driving portion based on the results of the quantitative analysis. When this is done we believe it is possible to build a propulsion mechanism with 10 percent efficiency based on this method.

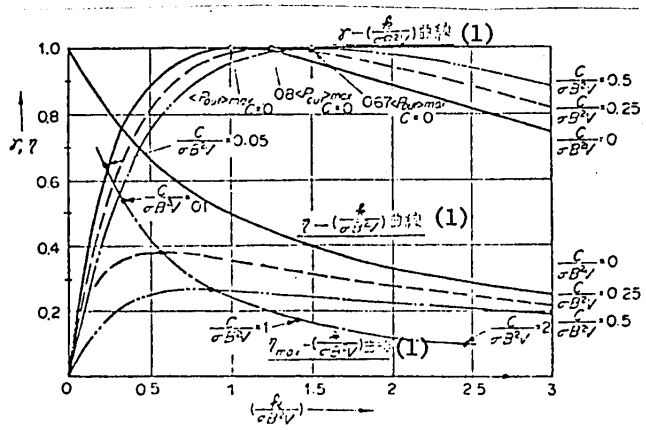


Figure 21. Relationships Between Efficiency Output and Load With Flow Loss as Parameter

Key: (1) Curve

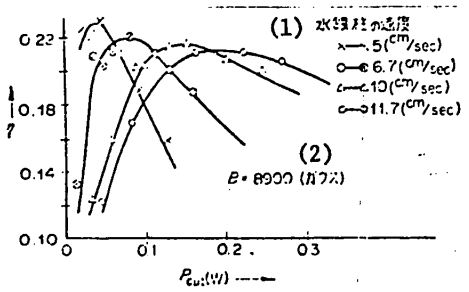


Figure 22. Relationship Between Efficiency and Output, With the Speed of Column of Mercury as Parameter (Source: Bibliography 13)

Key: (1) Speed of column of mercury (2) (Gauss)

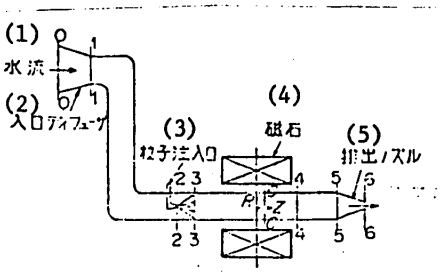


Figure 23. General Diagram of Water Jet Method Using Magnetic Sucking Force (Source: Bibliography 14)

Key:
(1) Water current
(2) Entrance diffuser
(3) Particle injection opening
(4) Magnet
(5) Discharge nozzle

4. Solid-liquid Two-phase Flow Method

McGowan and others have proposed a hydromagnetic waterjet, seen in Figure 23, based on the principle that when micron size iron particles, mixed into the seawater within the channel of a propulsion mechanism, are accelerated from the magnetic field, the seawater receives force due to viscous action.[14]

In the figure, the seawater flows in from section 0-0 and slurry-state solid particles are injected at section 2-2; the water is then acted upon by the magnetic field in the channel between sections 3-3 and 4-4 and jetted out from section 6-6. The iron particles move in the direction of the channel walls under the influence of magnetic field induced radius directional force within the solenoidal magnet; they are then recovered by a movable belt-like mechanism at section C-C. McGowan and others have calculated the propulsion

characteristics of this system, based on the values indicated in Table 4 and on the following suppositions: 1) The speed distribution of the fluid at the entrance of the flow is parabolic; 2) particles are evenly injected at the injection section; and 3) the total loss of waterhead from section C-C to section 6-6 can be ignored. Figure 24 shows the relationship between thrust force and particle density based on particle diameter and magnetic flux density as parameters. From the figure we see that the thrust increases as the diameter of a particle and flux density increase. Also, Figure 25 indicates the relationship between thrust per mass flux of the particle and the speed of the seawater at the entrance with flux density as parameter; it is acknowledged that when the speed at the entrance exceeds 100 (cm/sec), the thrust will decrease radically. The relationship between thrust per unit weight of the propulsion mechanism and concentration of the particles is as shown in Figure 26; it is obvious that only low thrust is obtained for the weights. For this reason, it is assumed that this method has application only within the range of control propulsion devices for major propulsion systems.

Table 4. Values Used in Calculating Propulsion Performances

Fluid's inflow speed on the center line, Uin (cm/sec)	10-5000
Radius of coil, rs (cm)	1
Length of coil (cm)	10
Distance between magnetic surface and section 3-3	10
Maximum magnetic flux density, B_{max} (kilo gauss)	50-500
Diameter of particle, dp (μ)	1-30
Particle density at entrance (number of particle/cm^3)	1×10^4 - 1×10^6

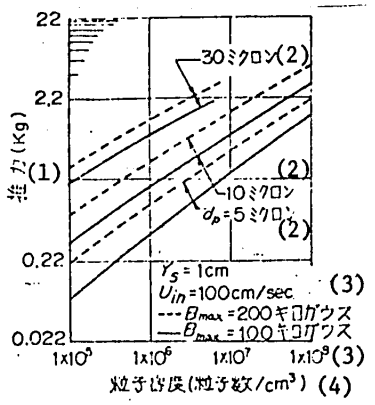


Figure 24. Relationship of Propulsion System's Thrust Against Particle Density and Particle Diameter (Source: Bibliography 14)

Key:
(1) Thrust (kg)
(2) Micron
(3) Kilo gauss
(4) Particle density (number of particle/cm^3)

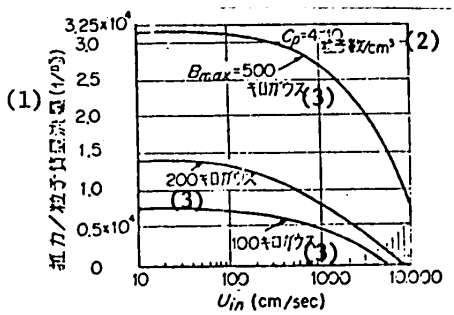


Figure 25. Relationship of Thrust Per Particle Mass and Flux Against Magnetic Flux Density and Fluid Entrance Speed (Source: Bibliography 14)

Key:
(1) Thrust/particle mass and flux (1/hour) (3) Kilogauss
(2) Number of particle/cm^3

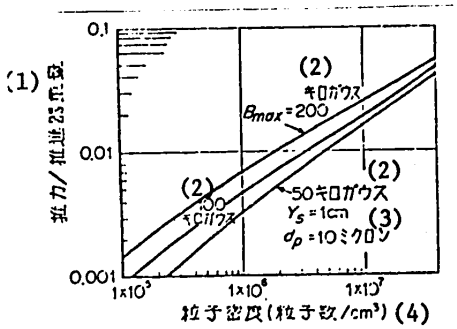


Figure 26. Relationship of Thrust Per Weight of Propulsion System Against Magnetic Flux Density and Particle Density (Source: Bibliography 14)

Key:
(1) Thrust/weight of propulsion system
(2) Kilogauss
(3) Micron
(4) Particle density (number of particle/cm^3)

5. Conclusion

We have studied the various electromagnetic propulsion methods whic have advantages under submerged conditions (especially, in extremely deep waters) over conventional propeller methods; we have categorized each system by working fluids, studied the principles involved, propulsion performances, and some problematic areas. As a result, it became clear that the method using seawater has lower propulsion efficiency due to poor conductivity of seawater, and that higher efficiency must await the development of superconducting magnets. Thereupon, a method using liquid metals as a small-scale propulsion mechanism

which uses a low magnetic field of several thousand gauss was conceived. As a result of our study of the propulsion performances, we can be hopeful that, with further improvements, a propulsion system with efficiency for greater than 10 percent can be realized. In addition, we have discovered that the solid-liquid two-phase flow system that mixes iron particles with seawater can be used only for something like the control propulsion device for major propulsion systems because its thrust per propulsion weight, even if iron particles can be recovered efficiently, is small. From above, we believe that in order to develop a small propulsion system which is desirable for marine exploration, we must thoroughly examine the liquid metal method and accurately grasp the problems which hinder its actualization.

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